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DNA 6132F

SXTF DESIGN SUPPORT

TRW Electronics and Defense Sector
Survivability and Test Technology Department
2340 Alamo Ave SE, Suite 200
Albuquerque, New Mexico 87106

30 September 1981

Final Report for Period 1 June 1981—31 July 1981

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Report summarizes design effort on the SXTF in several areas. Design requirements are developed for the satellite handling fixtures. A method is developed for providing spacecraft power. Thermal design requirements are provided.

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LIST OF ILLUSTRATIONS

INTRODUCTION

This report summarizes the activities performed under the proposed follow-on to contract DNA001-79-C-0134. TRW received contract go-ahead on 16 June 1981 and a stop work order on 16 July 1981. During this month four tasks were initiated and initial results were obtained on two. The tasks and results are given in the discussions below.

Task 2. Test Support Fixture Design

"Do a conceptual design of the test object support system. This task includes only that portion of the support system which the facility will provide to every user. Mechanical and electrical interfaces with which user-specified equipment must mate shall be defined."

Previous studies had suggested the following set of requirements for the test support system.

- o Translation

o Maximum rate	1 ft/min
o Maximum acceleration	0.5 g
o Maximum jerk	0.5 g/sec
o Accuracy	6 inches

- o Rotation

o Maximum rate	3°/min
o Maximum acceleration	$0.125°/sec^2$
o Maximum jerk	$0.125°/sec^3$
o Accuracy	1°

The translation and rotation limitations were derived from the FLTSATCOM spacecraft. New, undesigned spacecraft may be further limited/restricted or they may tolerate greater loads or accelerations depending on their peculiar design features. Therefore, the suspension system design requirements provided to the A&E should accommodate a degree of latitude which would permit the user to meet his own limitations and at the same time permit faster movements where tolerable. By adopting overhead bridge crane speed specifications the objectives of the users can be met. Accepting the limitations as

originally stated, the suspension system design criteria which should be provided to the A&E should read as follows:

- Speeds
  - Rotation: 0 to 1 rpm
  - Translation: 0 to 30 fpm
  - Hoisting: 0 to 20 fpm

- Control System
  - Dial (potentiometer) control as opposed to stepper switches.
  - Redundant stop switches; i.e., potentiometer off, in addition to a stop switch.
  - Direction switches are labeled and related to positioning within chamber.
  - The control panel should incorporate human factor design to minimize error in operation selection.
  - A programmable feature of the control system would be desirable to prevent or minimize risk to spacecraft hardware by providing a capability to specify speeds for a particular application and thereby remove the human factor from the operation.

Off center loading has not been addressed previously. However, an extreme condition could be hypothesized as a situation where the center of gravity of the 10,000 pound satellite was positioned one foot off center, resulting in 10,000 foot-pounds coupled about the central pivot point.

Task 3. Facility Power Interface

"Do a conceptual design of the facility portion of the spacecraft powering (i.e., battery charging) subsystem. This should include tank penetration(s), method of attachment at the inner tank wall, method(s) of approach and withdrawal, method(s) of electrical connection, remote connect/disconnect methods under vacuum, and method to provide facility power to a variety of test objects. The contractor shall clearly show where the interface(s) between facility and user-provided equipment

should occur. The contractor shall also specify types of materials to be used, consistent with the requirement to avoid in-chamber contamination."

Two possible umbilicals were designed for a satellite x-ray test facility (SXTF). One design incorporates a belt-pulley arrangement for bringing power terminals together. The second concept employs an "Astromast", to perform the same function. The belt-pulley system is desirable because of low initial cost, while the "Astromast" system is superior from the standpoint of maintenance, accessibility, compactness and retractive capability. Both systems will perform the required tasks reliably. The design requirements are:

1) The umbilical must attach to the spacecraft, between x-ray test exposures, to furnish electrical power, charge spacecraft batteries and provide necessary spacecraft electrical control signals.
2) The umbilical must be compatible with a thermal vacuum environment.
3) The umbilical must disconnect/retract from the spacecraft prior to x-ray exposure.
4) The spacecraft/umbilical interface should be small to minimize effects upon the spacecraft's electromagnetic response.

The belt-pulley system (see Figures 1 and 2) consists of a continuous belt stretched between an upper pulley, located near the thermal-vacuum chamber ceiling, and a lower pulley near the spacecraft. The belt is constructed of laminated Kapton, which remains flexible at an extremely cold temperature(-280°F). The belt is 3 to 6 inches wide, with a roller-to-roller length of approximately 750 inches. The two pulleys are mounted on spring loaded structures, which accommodate adjustment of pulley center-to-center distance in the event of change in spacecraft orientation and belt length. The pulley material is phenolic, which is compatible with thermal vacuum environment. A fiberglass plate is attached to the belt, upon which the electric power terminals are mounted. Flat "ribbon" cable is used because of the orderly manner in which it unfolds. This type of cable is currently being used in a TRW

lightweight solar array design and has been extensively tested for mechanical characteristics. The pulley at the spacecraft interface is enclosed inside of a non-metallic box structure. Spacecraft power terminals are mounted to a bracket within the box and align with the belt electrical contacts. A short length of cable connects the power terminals to the spacecraft interface connector.

Electrical continuity between spacecraft and equipment outside the chamber is achieved when the belt terminals contact the stationary terminals located in the spacecraft interface box. The belt is driven by electric motor and gear drive assembly attached to the upper pulley unit. Mechanical stops, adjacent to the terminals, control belt motion so that the two sets of terminals are brought into direct contact. Prior to x-ray exposure, the belt is driven in the reverse direction and the power cable is retracted from the spacecraft and stored adjacent to the belt drive upper pulley.

The second umbilical system (shown in Figures 3 and 4) employs an "Astromast" for drive purposes. An "Astromast" is a deployable truss structure composed mainly of three longerons connected by slim tension members. An "Astromast" consists of three sections--storage, transition and drive. When retracted, the boom is "twisted" and stored inside of the storage section. When the drive motors are actuated, the drive section rotates visibly, deploying the boom. In the transition section the stowed boom elements are "straightened" as they are deployed. The thin tensile members situate themselves in such a fashion to give the boom great strength and stiffness. "Astromasts" can be fabricated to different sizes, strengths, stiffnesses and lengths, as necessary. A 15-foot "Astromast" is currently being used in TRW lightweight solar array testing and has functioned dependably throughout six months of testing. The "Astromast" stores in a very compact volume, approximately 18 inches diameter by 3 feet.

Electric connectors are fastened to the "Astromast's" faceplate. As with the belt-pulley system, flat "ribbon" cable is used and deploys

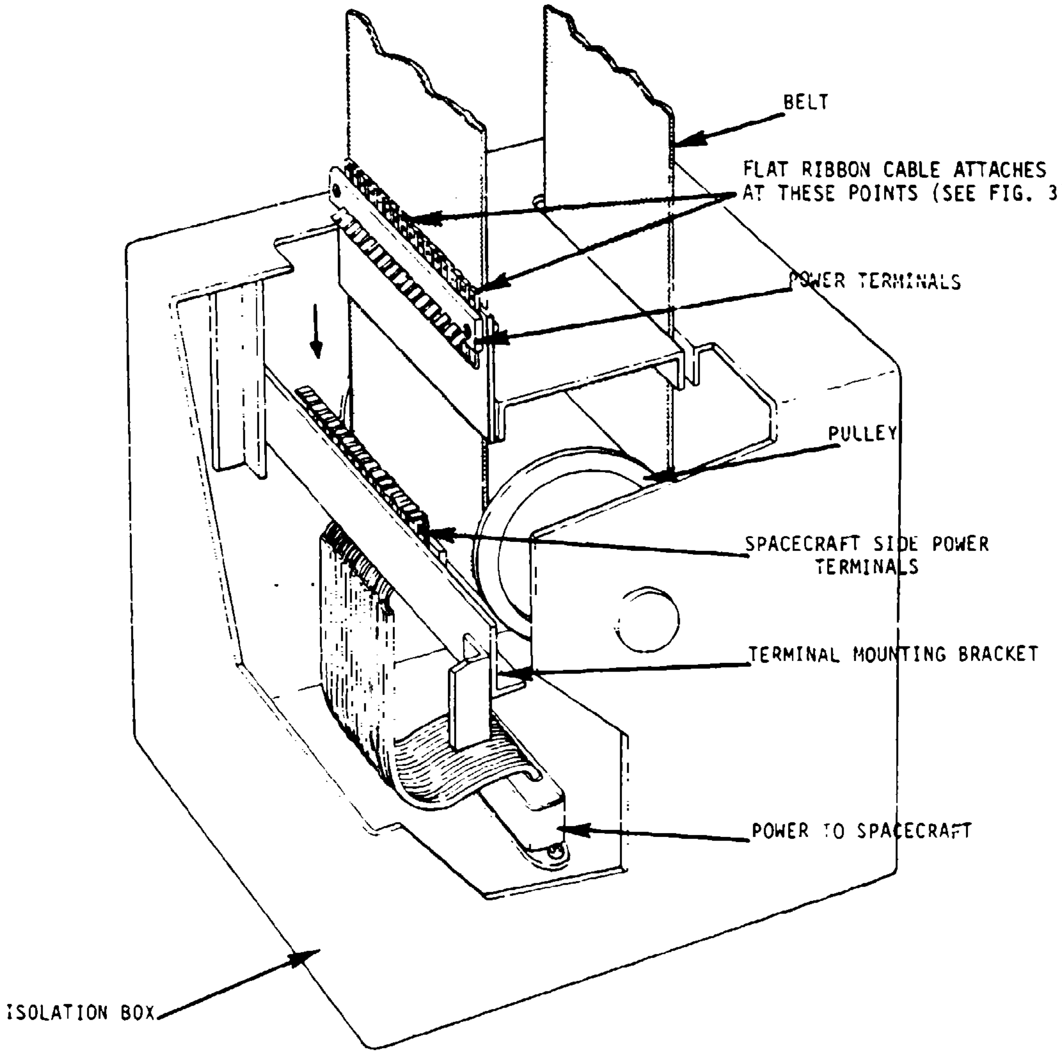

Figure 1 - Belt Pulley Umbilical System

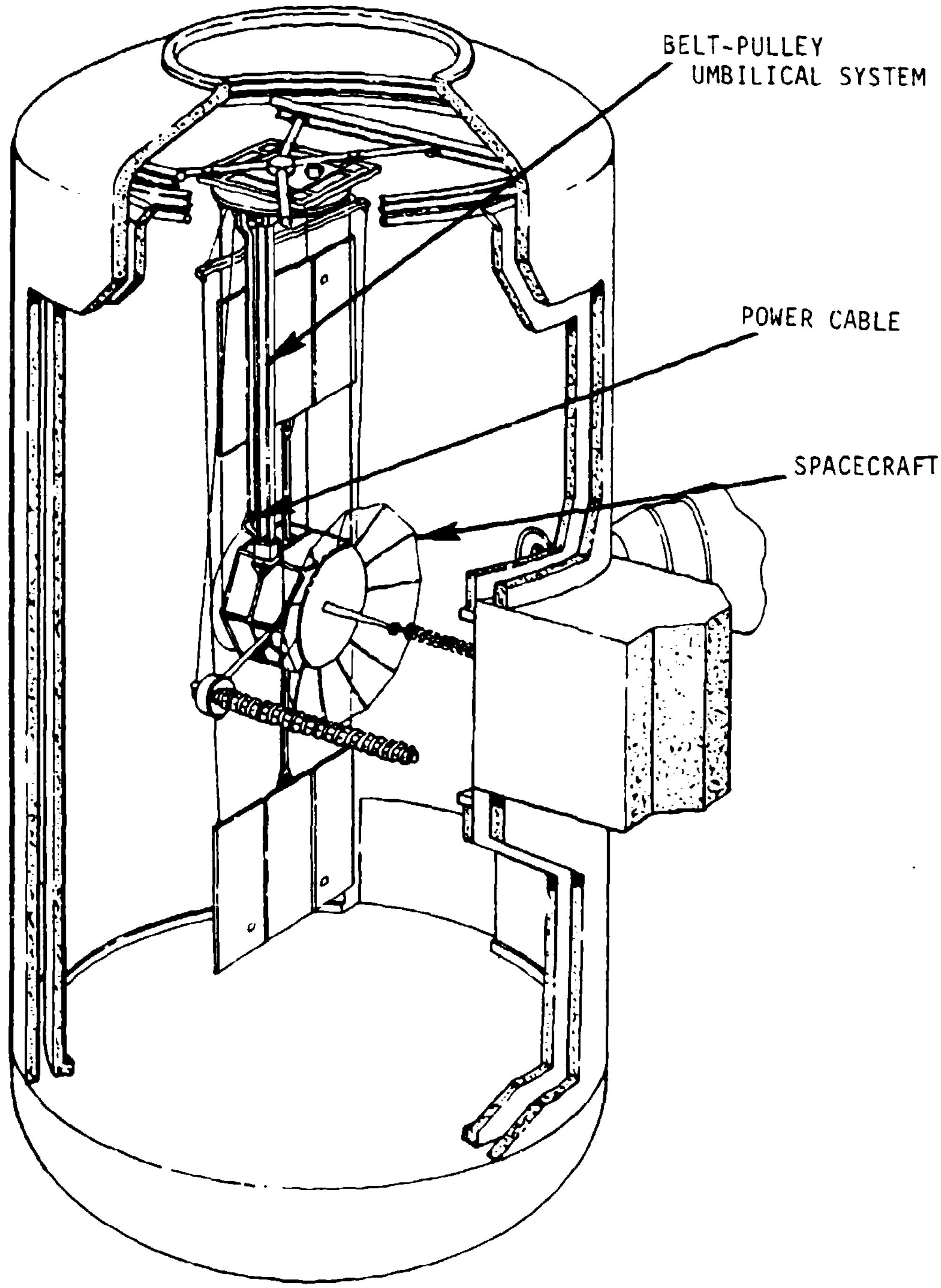

Figure 2 - Belt Pulley Umbilical System Inside of a Vacuum Chamber

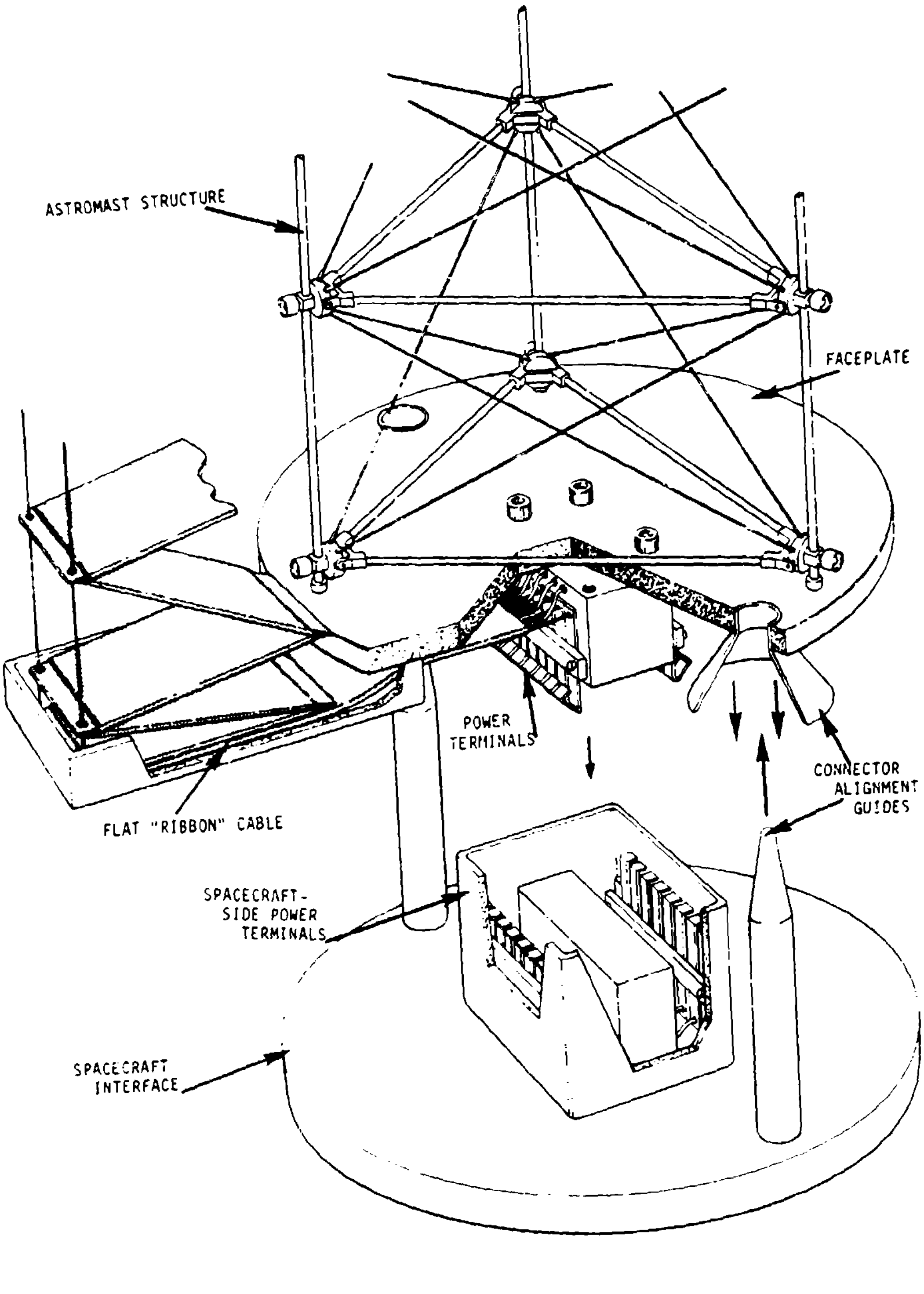

Figure 3 - Astromast Umbilical System

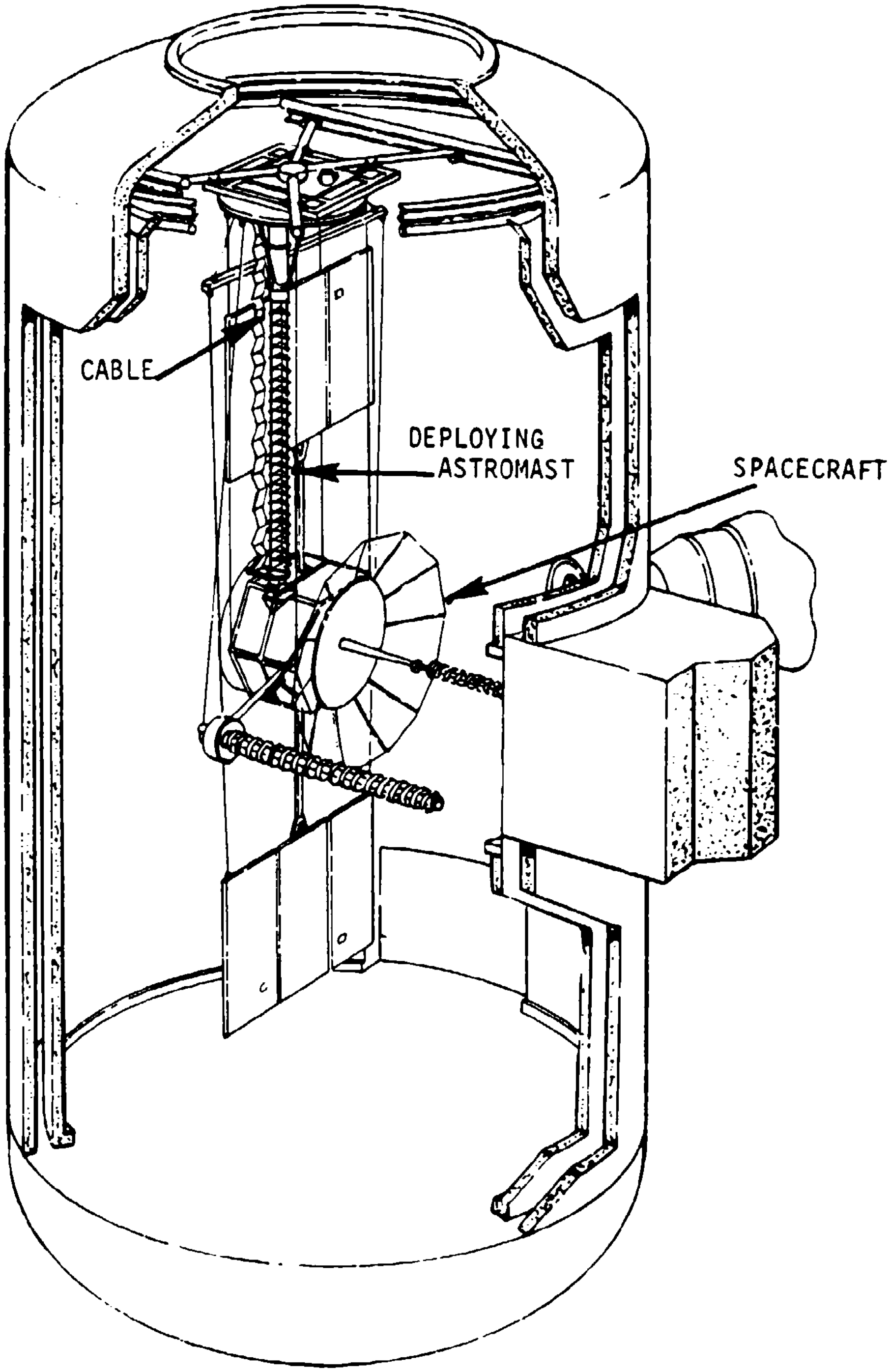

Figure 4 - Astromast Umbilical System Inside of a Thermal Vacuum Chamber

from a position alongside the "Astromast" housing. Conical guides (see Figure 3) are attached to the faceplate. For proper connector alignment, these guides are mated to pins, which are fastened at the spacecraft interface. The "Astromast" should be mounted to a two-axis gimbal, which functions as a universal joint. The gimbal permits adjustment of the "Astromast's" attitude when the spacecraft interface is not precisely located under the "Astromast". Electrical continuity between spacecraft and equipment outside the chamber is achieved when the "Astromast" is deployed toward the spacecraft interface and power terminals connected. The guides on the faceplate mate with the pins on the interface as the terminals near connection. The deployment of the "Astromast" is halted when the terminals are in contact prior to x-ray exposure. The "Astromast" is retracted from the spacecraft and stored at the top of the vacuum chamber volume. The "Astromast" is particularly desirable because of this retractive ability. During x-ray exposure, only the compact spacecraft interface would remain adjacent to the spacecraft.

Both umbilical systems will perform the required tasks reliably. The initial cost of the belt-pulley system is moderate, while the initial cost of the "Astromast" system is higher. The belt-pulley drive system requires more design effort and is composed of many separate parts (i.e., belt, pulleys, shafts, bearings). The "Astromast" drive system, on the other hand, is a single existing proven unit. Higher maintenance costs are more likely to be incurred with the belt-pulley system. The "Astromast" system will require less maintenance because of the durability of astromasts and the overall simplicity of the system. The "Astromast" system's most beneficial aspect is the total retractive capability of the "Astromast" boom. Prior to x-ray exposure, the boom can be completely retracted into its storage housing.

Conversely, the belt-pulley drive arrangement remains adjacent to the test article (spacecraft), at all times. The degree to which the belt-pulley system would disturb the spacecraft electromagnetic response may make the "Astromast" umbilical system the more acceptable design.

Task 5. Test Object Diagnostic Interface

"Do a conceptual design for a multiplex adapter to interface with the test-specific diagnostics/telemetry equipment at the test object on one side and the FOL transmitter on the other side."

Although effort was expended under this task, no reportable results were obtained prior to stop work.

Task 10. Test User Needs

"Continue to support DNA in providing recommendations and reviewing SXTF concepts concerning the following test user needs:

a. Establishing a realistic space environment, with emphasis on thermal requirements for various candidate spacecraft.
b. Industrial safety and radiation safety.
c. Security of personnel, of test articles and associated hardware, and of test results, data and analysis.
d. In-chamber handling and assembly of test articles.
e. Use of x-ray sources and associated equipment such as collimators, damper grid, absorbers and shields.
f. Effects of using UHF links in-chamber, given that this may be in-band to SGEMP sensors.
g. Supplying power to the spacecraft or to any test-related functions. Recommended testing where required to define or verify design approaches in any of these areas."

The major focus in this task was to help define the thermal requirements. The most pressing concern was the independent zonal control arrangement.

The latest design had included four azimuthal zones with the capability for independent azimuthal control. After reviewing DSP and FLTSATCOM designs TRW recommended that the four zone arrangement be provided. Furthermore, based on the DSP thermal information given in Figure 5, a split vertical control arrangement appears desirable. The solar panels on the lower cylinder have no internal heat source and will therefore eventually approach the temperature of the dominant cold wall in view.

Since a test limit of -50°F on the solar panels is observed, warmer walls on the lower half of the chamber in the "vertical" position would be required.

The initial revised chamber thermal requirements supplied to DNA were:

Coldwall

- 4 azimuthal zones on sides
  2 vertical zones on sides
- Each zone controllable independently with an effective wall temperature at -320°F or -200°F to 0°F
  (Note: -320°F is not <u>required</u>.)

Chamber Interior

- Non-shrouded areas--floor and ceiling--should have low emissivity ($\epsilon \leq .1$)
- Provisions for panels on floor and ceiling

Source Shield

- Highly convex
- Emissivities TBD.

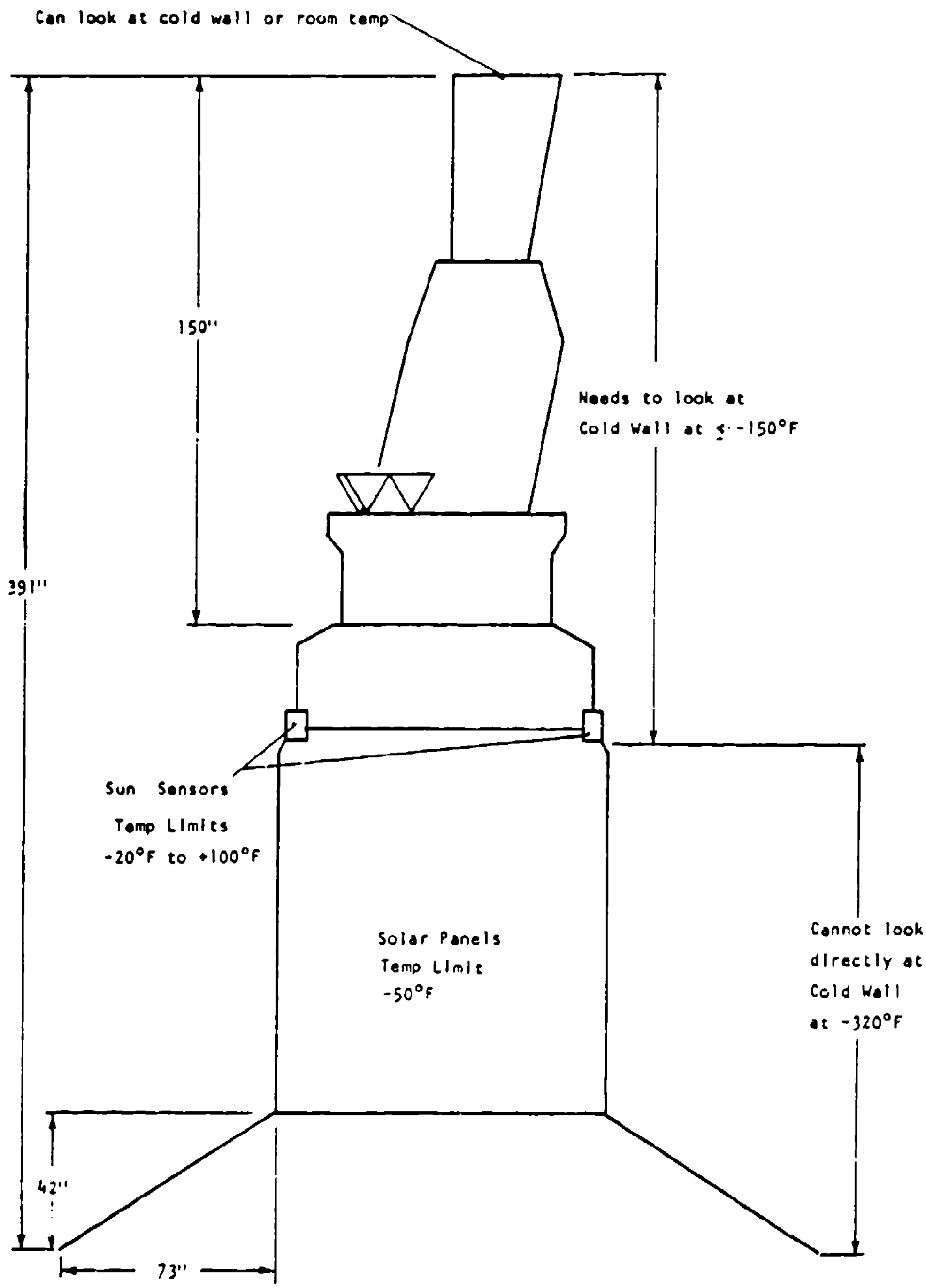

Figure 5. DSP Thermal Characteristics

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